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(54) Microscope turret

(57) A rotatable turret for a microscope has magnets in holes *5a*—*5c* forming a separate digital magnetic field code for each operative position of the turret. A stationary part of the microscope has magnetic field sensors for reading the code at any operative position to which the rotary turret is indexed or set. These sensors are in the form of Hall-effect sensors with built-in threshold switches. An electric motor turns the turret, and is controlled from a comparator circuit, one input of which receives the outputs from the magnetic field sensors, and another input of which receives the output from a keyboard which may be used to call up any desired position of the turret.

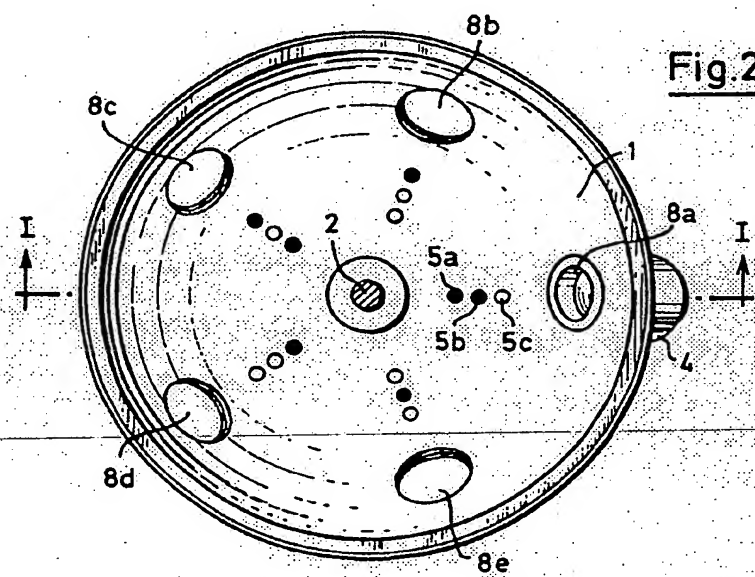

Fig.2

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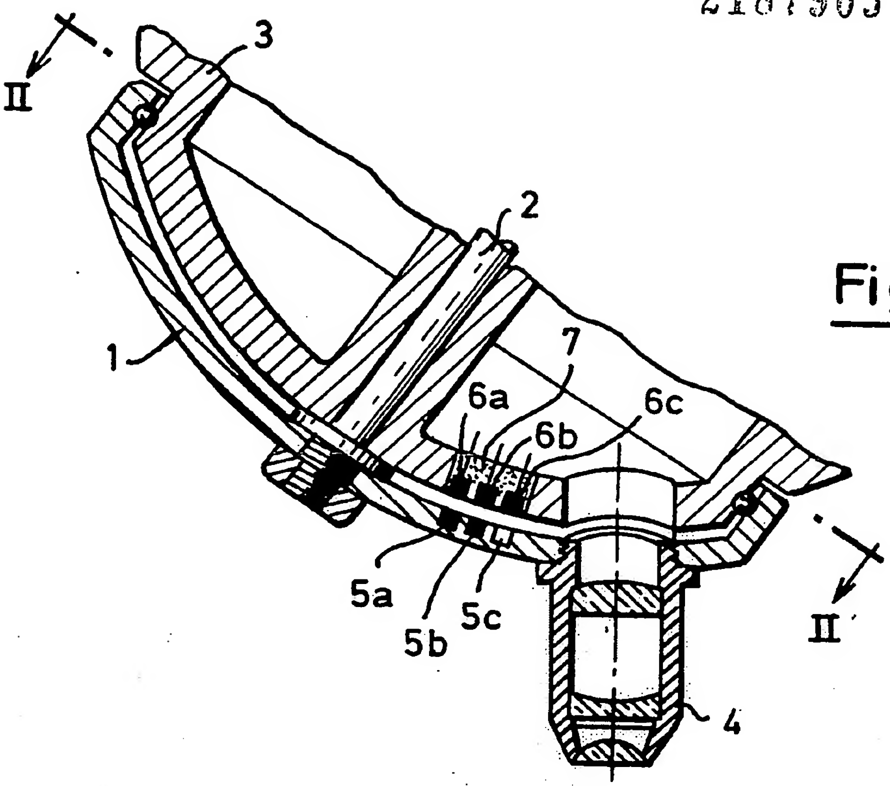


Fig.1

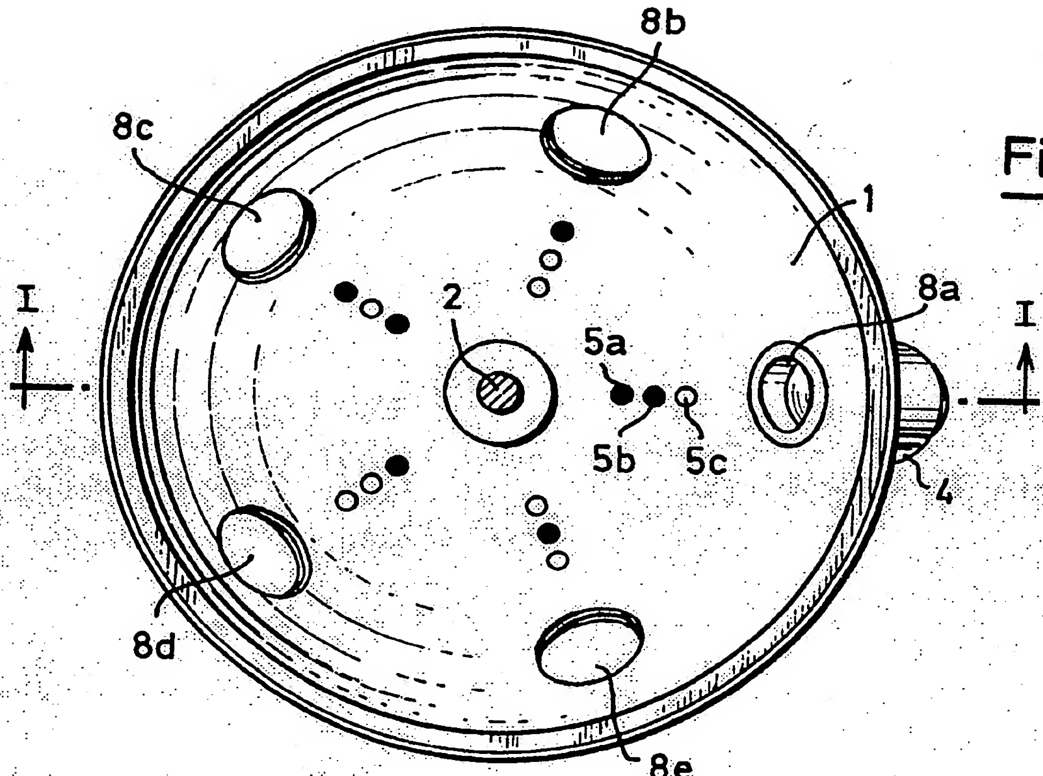
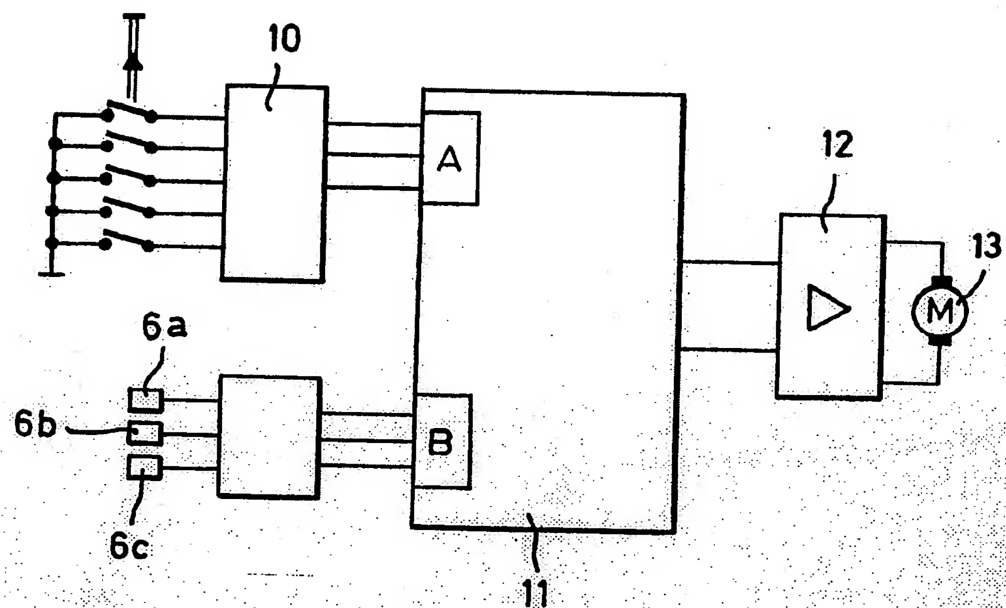


Fig.2

Fig.3



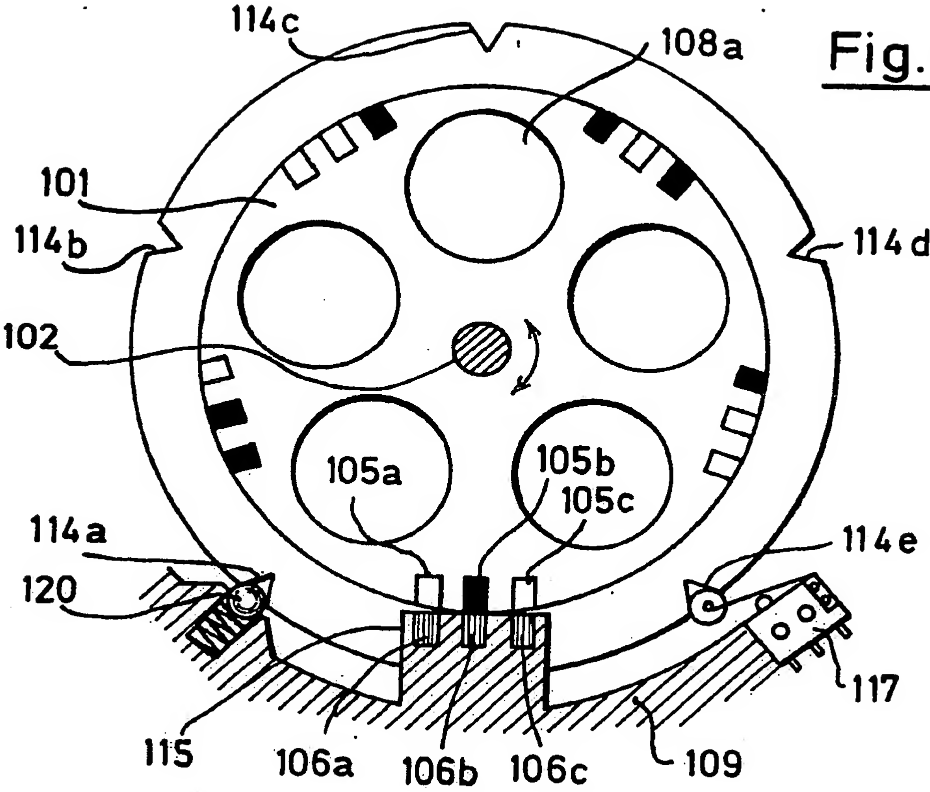

114c
108a
101
114b
114d
102
105a
105b
105c
114a
114e
120
117
115
106a
106b
106c
109

Fig.4

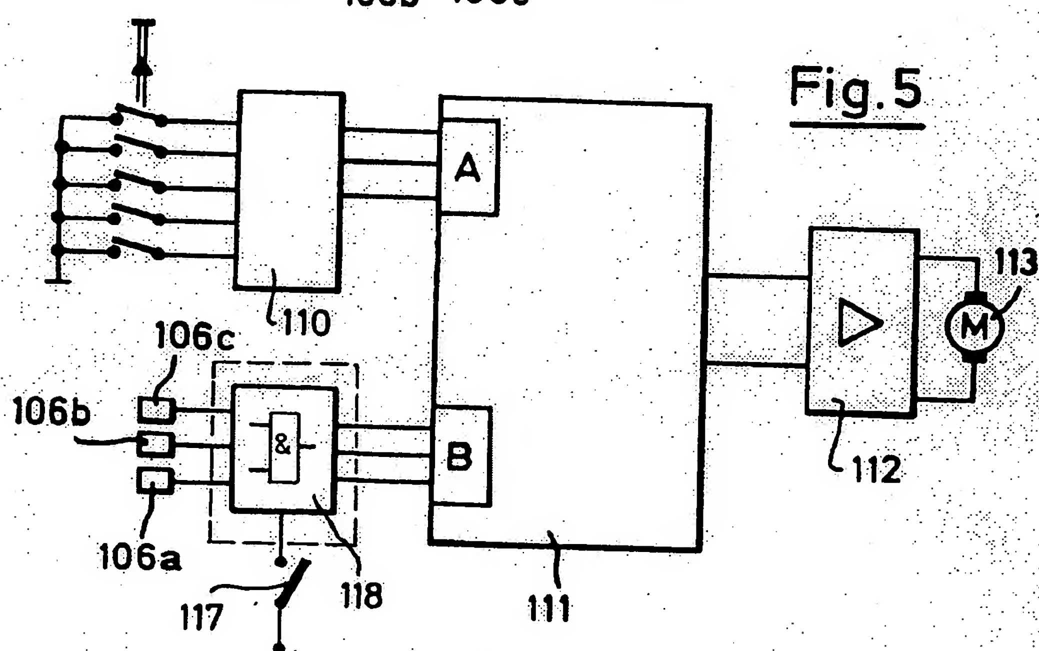

A
B
110
106c
106b
106a
&
118
117
111
112
113
M

Fig.5

SPECIFICATION

Microscope Turret

Background of the Invention

This invention relates to a turret for microscopes, and more particularly to means for reading the position to which the turret has been set or indexed, and utilizing the read-out information in various ways. The turret contains a plurality of optical elements selectively brought into operative position in an optical axis by turning or indexing the turret, as well understood in the art. As an illustrative example, the optical elements carried by the turret are shown as microscope objectives, the different objectives on the turret being selectively brought into the optical viewing axis of the microscope by turning the turret, but the invention is equally applicable to other types of optical elements on the turret, such as filters, aperture stops, or lenses other than objectives, and the turret may be in an illumination optical axis rather than an observation or viewing optical axis, both locations of turrets being well known in the art.

Various devices for indexing the turret or reading the position of the turret are known in the art. For example, Federal Republic of Germany Auslegeschrift 22 19 521 (A. Dehlink/C. Reichert Optische Werke) discloses indexing means used in order to adapt to optical elements in the illumination ray path to the particular lens that has been switched into place in the instantaneous position of the turret carrying a series of objectives. For this purpose the device contains either cam disks or electric contacts which are connected to resistors of different size. Both solutions are based on a contact scanning between the movable turret shell and the mounting thereof, and are therefore subject to wear and disturbance. As a variant, optical scanning without physical contact has been described in connection with Fig. 5 of the document, but such scanning is not of the turret shell or dish itself, but rather scanning of the lenses screwed into it. Such an optical scanning of the lenses is proposed also in Federal Republic of Germany patent 28 46 655 and its corresponding U.S. patent 4,241,251 granted Dec. 23, 1980 (K. Yonekubo). This arrangement results in difficulties due to the uncertain angular position of the lens which is screwed in.

Also from Federal Republic of Germany patent 32 02 461 and its corresponding U.S. patent 4,515,439 granted May 7, 1985, (K. Esswein), it is known to scan the lenses themselves without contact. In that case, a digital code is provided on the rear of each lens, which is also provided with a bayonet type of attachment to the turret. Thus special lenses must be used, and also the reading of the digital bar code must take place dynamically, that is, while the turret is moving into its indexed position. A reading of the turret position can not be taken statically, while the turret is stationary.

From Federal Republic of Germany patent 31 45 615 and corresponding U.S. patent 4,432,627 granted Feb. 21, 1984, (Mizokami), it is known to provide a magnetic coding (e.g., in the form of magnets of different strengths) on photographic lenses and to provide a single magnetic-field sensor on a camera housing or body for the recognition of the code when a particular lens is mounted on the camera body. This sensor is connected to a level discrimination circuit which evaluates the analog signal with a resolution which is dependent on the number of different lenses. Such an analog coding requires the maintaining of very small mechanical tolerances and an accurate balancing of the electronic components, and is relatively susceptible to disturbance, for instance to aging.

Summary of the Invention

An object of the present invention is to equip the turret of a microscope, especially but not exclusively the turret which carries the objective lenses, with a device for indexing or reading the turret position which operates without contact, which is of simple contruction and not susceptible to disturbance, and which is suitable for reporting the turret position back to a motor which drives the turret.

According to the invention, this object is achieved by providing, on the rotatable turret shell or dish, separate magnetic digital code means formed by one or more magnets for each of the different operative positions of the turret, and a plurality of magnetic-field sensors on a stationary part for recognition of the code.

This solution has the advantage that the turret shell can be very easily coded even after it has been manufactured. Also, commercially available components, for example Hall-effect elements with built-in threshold switch, can be used for the code scanning or recognition. The signals of the Hall-effect elements can be compared in digital form directly with desired values which can be inputted by means of a keyboard in a control console, so that high assurance against noise is provided at only slight electronic expense.

Further advantages of the invention can be noted as the description proceeds.

Brief Description of the Drawings

In the accompanying drawings, which illustrate exemplary embodiments of the invention,

Fig. 1 is a diametrical axial section through the rotary shell of an objective turret and a fragment of the stationary or base part of the turret, illustrating one form of the invention, the section being taken approximately on the line I—I of Fig. 2;

Fig. 2 is a view of the inner face of the turret shell of Fig. 1 with its axle in section, taken approximately on the line II—II of Fig. 1;

Fig. 3 is a schematic block diagram of the electronic system used in connection with utilizing the signals resulting from the code arrangement shown in Figs. 1 and 2;

Fig. 4 is a view of the inner face of a rotary turret shell and a fragment of the associated stationary part of the turret, illustrating a second embodiment of the invention; and

Fig. 5 is a schematic block diagram of the electronic system used in connection with the embodiment of Fig. 4.

Description of the Preferr d Embodiments

Referring now to th first embodiment illustrat d in Figs. 1 and 2, there is a rotary turret shell or dish 1 the axle 2 of which rotates in the stationary part 3 of the turret. The shell has any desired number (five being here shown) of circumferentially arranged and equally spaced threaded openings or receptacles 8a, 8b, 8c, 8d, and 8e, into which may be screwed any desired optical elements such as objectives, only one of which is shown at 4, screwed into the opening 8a, but it will be understood that other objectives of differing focal lengths, for example, would be mounted in the other threaded openings.

Associated with each of these threaded openings, and in the same definite spaced relation to its respective opening, there is a series of three holes 5a, 5b, and 5c, so that there will be a total of fifteen such holes if there are five threaded openings in the turret shell. In one or more of the holes of each set or series, there is a permanent magnet inserted and retained in any suitable way, such as by adhesive. The magnets are arranged according to an unambiguous digital code, that is, a separate code for each row of holes. For example, the holes associated with the threaded opening 8a may have magnets in the inner and middle holes 5a and 5b respectively, with no magnet in the outer hole 5c; the holes for coding the opening 8b may have a single magnet in the outer or "c" hole with none in the "a" and "b" holes; the holes for coding the opening 8c may have magnets in the inner and outer "a" and "c" holes, respectively, with none in the middle or "b" hole; the holes associated with the opening 8d may have a single magnet in the inner or "a" hole with none in the "b" and "c" holes; and the holes relating to the threaded opening 8e may have a single magnet in the middle or "b" hole, with none in the "a" and "c" holes. This is merely an example of a possible coding arrangement, since the magnets may be arranged in the holes in a great variety of ways, so long as they provide an unambiguous digital code, unambiguous in the sense that the code is recognizably different with respect to each threaded opening containing an optical element.

For reading the code provided by the magnets on the turret shell, the stationary part of the turret is provided with three elements 6a, 6b, and 6c which are responsive to the magnetic fields of the magnets in the turret shell when in close proximity thereto and which are positioned in a slot 7 formed in the stationary member 3 and held therein by any suitable means such as adhesive. These magnetic-field sensors are conveniently in the form of Hall-effect elements which are available on the commercial market, one suitable kind being the type with built-in threshold switch, sold by Texas Instruments under the designation TL172. They are located on the stationary part 3 of the apparatus in a position where they will be directly in line with a set of holes and magnets of the rotary shell when the shell is turned or indexed to bring the optical elem nt associated with that set into the desired optical axis. Such a position is illustrated in Fig. 1.

In such a position of the turret, the code is read by the thre Hall-effect lements 6a—6c. For example, in the showing of Fig. 1, the two magn ts 5a and 5b are opposite the sensors 6a and 6b, and there is no magnet in the vacant hole 5c opposite the sensor 6c. The Hall-effect elements therefore give a parallel signal which corresponds in binary code to the digit three, and characterizes the lens which is now in effective position at the optical axis.

The magnet-receiving holes in the turret shell may be in various locations, depending on available space in the turret, so long as each set or series of holes is in the same definite relation to the threaded opening with which it is associated, and so long as the sensors are correspondingly placed with respect to the optical axis with which the optical elements on the turret are to be aligned. In the arrangement shown in Figs. 1 and 2, the magnet-receiving holes are in radial lines extending from the axle 2 to the center of the associated respective threaded opening, but each adial line of holes could equally well be offset a definite angle from the associated threaded opening, if the sensors were correspondingly offset.

Referring now to Fig. 3, the signal from the sensors is fed to the input B of a comparator 11. The input A of this comparator is connected to receive its input from the output 10 of a keyboard shown schematically in a control console not otherwise shown.

At the control console, the lens to be brought into operating position can be called up by depressing one of the individual keys marked with an identifying legend corresponding to a particular one of the lenses on the turret. The number of keys will correspond, of course, to the number of lenses mounted on the turret, five keys being here shown (Fig. 3) since there are five lenses on the turret, but as above stated, the turret could have more or less than this number. Preferably the keys are so designed that the identifying legends thereon are exchangeable or replaceable, so that the user can mark the keys himself, according to whatever lenses (or other optical elements) he chooses to mounted on the turret.

Upon actuation of a key, the output of the keyboard delivers a code which is compared in the comparator circuitry 11 with the output from the sensors 6a—6c. If the actual or present position of the turret does not agree with the desired position called for by the depressed key the comparator 11 gives an output signal to the control circuit 12 of the motor 13 which is operatively connected in conventional manner to the turret to turn the turret shell. The motor then turns the turret shell until both codes agree at the inputs A and B of the comparator 11. When both codes agree, the motor stops, and a conventional ball detent of known type (not shown) engages in a notch on the turret shell to produce accurate centering and fine positioning of the turret shell 1, to place the desired lens precisely in the optical axis of the microscope.

The comparator also contains a m mory into which the sequence of the different codes of the turret shell is entered. A logic circuit insures that the

rotation of the motor 13 takes place in the direction providing the minimum rotation from the previous turret position to the new desired turret position. As a result, the time required for the change is minimized.

It is clear that the output signals of the sensors 6a—6c can be used to control further functions in the microscope, such as stops or lens systems in the illumination ray path or units indicating, for instance, the magnification for which the microscope is set.

In the specific embodiment illustrated in Figs. 1 and 2, the Hall-effect sensing elements and the associated groups of coding magnets are arranged in radial lines, those on the shell being radii from the axle 2 to the respective threaded openings 8a—8e. It has been mentioned above that the radial lines may be offset angularly from the threaded openings, and such position may be advantageous when there are problems with regard to available space within the turret shell. Also, other arrangements of the magnets may be used, for instance, spacing the magnet holes of each group circumferentially on a circle concentric to the axle 2.

Such an embodiment is shown in Fig. 4. In this case the turret shell 101 is provided with the threaded openings or receptacles 108a etc., to receive the lenses or other optical elements. The shell is rotatable on or with the axle 102. The turret shell is furthermore provided with V-shaped notches or grooves 114a—114e, one for each threaded opening. These notches cooperate with a spring pressed ball detent 120 which enters resiliently in a notch to determine accurately the indexed position of the turret, so that the lens will be precisely on the optical axis. The ball detent is mounted on a stationary part 109 of the turret or of the microscope stand. This is the kind of detent (known in the art) which was mentioned but not illustrated in connection with the embodiment of Figs. 1—3.

Five groups of three holes each are arranged on the outer periphery of the turret (assuming, of course, that the turret is to carry five lenses or other elements). These holes receive the permanent magnets which are associated with the switch positions of the turret, the magnets being shown black in Fig. 4. The three holes of one group are identified by the numerals 105a—105c, the holes of the other groups being not specifically numbered.

On the stationary part 109, there are three magnetic-field-sensing elements 106a—106c, such as Hall-effect elements of the kind previously described in connection with the first embodiment. These sensor elements 106a—106c are so placed that in the switched positions or detent-determined positions of the turret shell, the sensor elements will be directly opposite and aligned with a set of three holes containing the coding magnet or magnets, as clearly seen in Fig. 4. One or two magnets are placed in each set or group of three holes, positioned to form a digital code as already explained in connection with Figs. 1 and 2, the magnets being so oriented that their magnetic fields are pointed radially outwardly so as to be read by the sensors 106a—106c.

Since the coding magnets and the Hall-effect sensing elements are arranged on a circle concentric to the axle 102, the Hall-effect elements will first of all give false code signals as the turret, in its rotation, approaches a detent position or indexing position. In order to suppress the processing of such false signals, there is a microswitch 117 mounted on the stationary part 109. The operating arm of this switch carries a roller which engages in one of the notches 114a—114e when the turret is in one of its proper indexed positions, thus shifting the control switch 117 to a position allowing the outputs from the sensors 106a—106c to pass to the input B of the comparator 111. However, while the turret is turning, the switch-arm roller is forced out of the notch, and this shifts the switch to a position activating the control switch 118 through which the sensor outputs are connected to the comparator input B, so that the sensors can not transmit the false signals to the comparator.

The comparator 111 in this embodiment corresponds to the comparator 11 in the previous embodiment, and operates in the same way as previously described. The keyboard and the parts 110, 112, and 113 of this embodiment correspond to the keyboard and parts 10, 12, and 13 respectively previously described, and thus need no further description or explanation.

As already indicated, other turrets in the microscope, such as stop or aperture turrets, filter turrets, or illumination ray path turrets, may have their positions read or determined, and may be rotated or indexed to desired positions, in the same way herein disclosed for the turrets here illustrated.

CLAIMS

1. A turret for a microscope comprising a rotatable part having a plurality of optical element holding means for holding a plurality of optical elements to be individually brought into effective operating position by turning said rotatable part, means forming a plurality of magnetic field coding areas on said rotatable part, one associated with each of said element holding means, each of said coding areas including at least one magnet, the respective magnets being arranged to form digital codes with the code of each area differing from the codes of all other areas, and a plurality of magnetic-field sensors positioned to sense and recognize the code of an area when said rotatable part is turned to bring such area into proximity to said sensors.

2. The invention defined in claim 1, wherein said magnetic-field sensors are Hall-effect elements having a built-in threshold switch.

3. The invention defined in claim 2, further comprising means forming a comparison circuit having a first input and a seocnd input, a control console for said microscope, said console including a keyboard, means for delivering output from said sensors to one input of said comparison circuit, and means for delivering output from said keyboard to another input of said comparison circuit.

4. The invention defined in claim 3, further

comprising a motor operatively connected to said rotatable part to turn said part, electronic control circuit means for said motor, and means for delivering output from said comparison circuit to said electronic control circuit to control operation of said motor.

5. The invention defined in claim 3, further comprising a control circuit for controlling delivery of output from said sensor to said comparison circuit, a plurality of notches on said rotatable part of said turret, and a switch for controlling said control circuit, said switch being responsive to said notches.

6. The invention defined in claim 5, wherein said notches are in such relation to said optical element holding means and said switch is in such relation to said notches and to said control circuit, that output from said sensors is delivered to said comparison circuit only when said rotatable part of said turret is in an optically correct position with one of said optical element holding means accurately aligned with an optical axis, thereby suppressing any false reading detected by said sensors during movement of said rotary part toward an optically correct position.

7. The invention defined in claim 6, wherein said optical elements are lenses.

8. The invention defined in claim 1, wherein said optical elements are lenses.

9. The invention defined in claim 1, wherein said means forming magnetic field coding areas comprises a series of three holes associated with each of said element holding means, each of the holes being adapted to receive a magnet, and a magnet in at least one hole of each series of holes, the respective magnets being differently arranged in the holes of the different series so as to form different codes.

10. The invention defined in claim 9, wherein the three holes of each series are arranged along a line which is radial with respect to an axis of rotation of said rotatable part of the turret.

11. The invention defined in claim 9, wherein the three holes of each series are arranged circumferentially along a circle which is concentric with respect to an axis of rotation of said rotatable part of the turret.

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